

A Renewed Spirit of Discovery:



NASA Cell Science
Investigator's Workshop
February 27, 2004

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Office of Biological and Physical Research



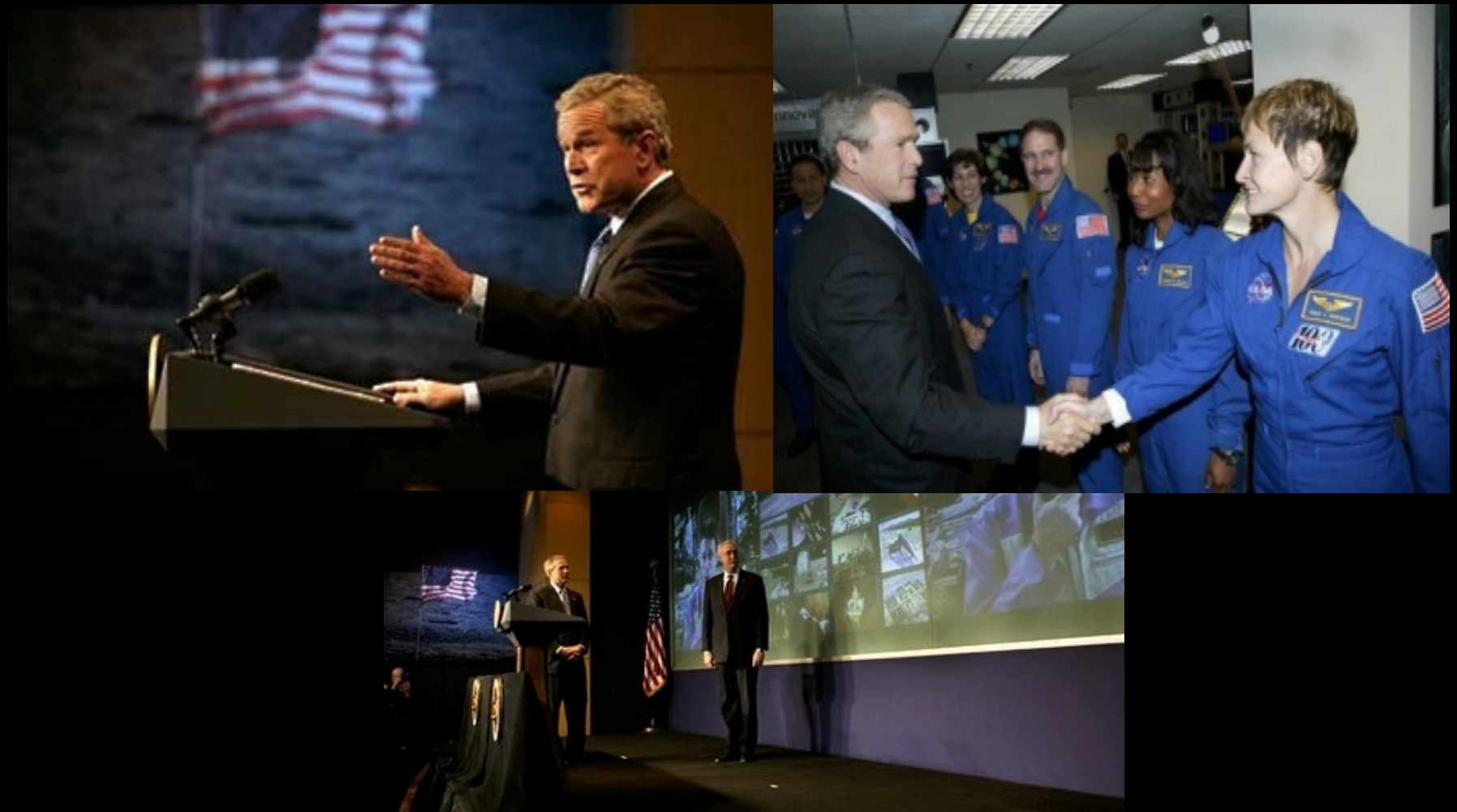
The NASA Vision

To improve life here,
To extend life to there,
To find life beyond.

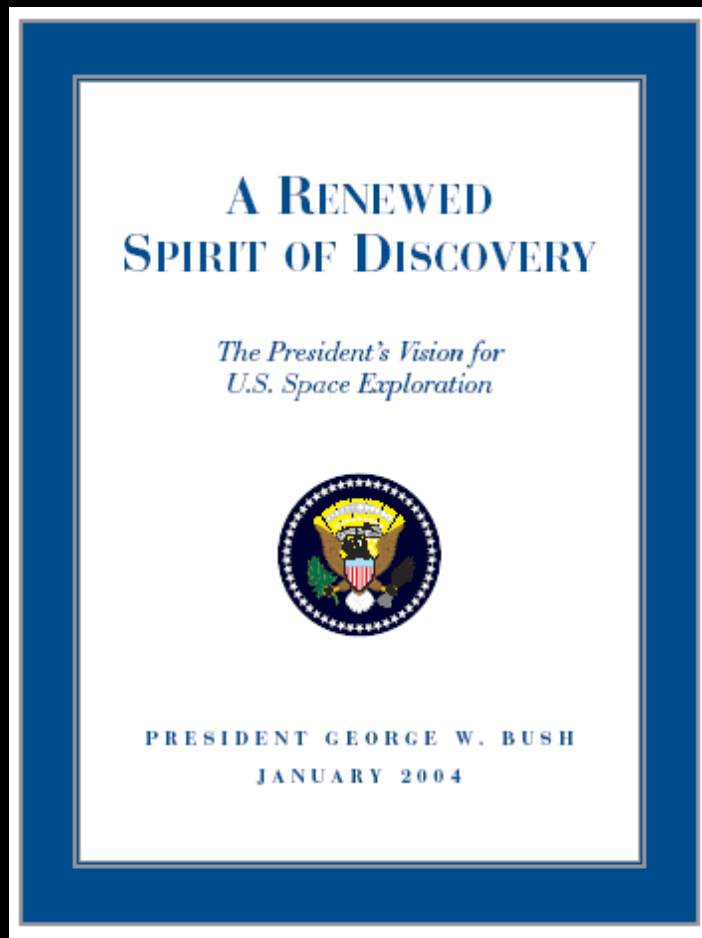
The NASA Mission

To understand and protect our home planet
To explore the universe and search for life
To inspire the next generation of explorers
...as only NASA can

On January 14, 2004, President Bush established a new vision for U.S. space exploration



The President's vision is documented in *A Renewed Spirit of Discovery, The President's Vision for U.S. Space Exploration.*



"This cause of exploration and discovery is not an option we choose; it is a desire written in the human heart."

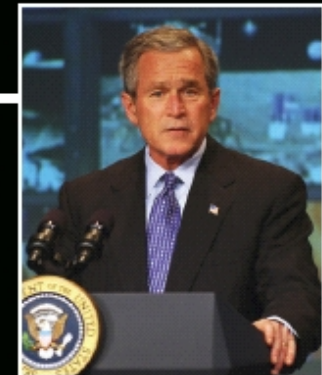
President George W. Bush
February 4, 2003

"We leave as we came, and God willing as we shall return, with peace and hope for all mankind."

Eugene Cernan (Commander of last Apollo mission)
December 17, 1972

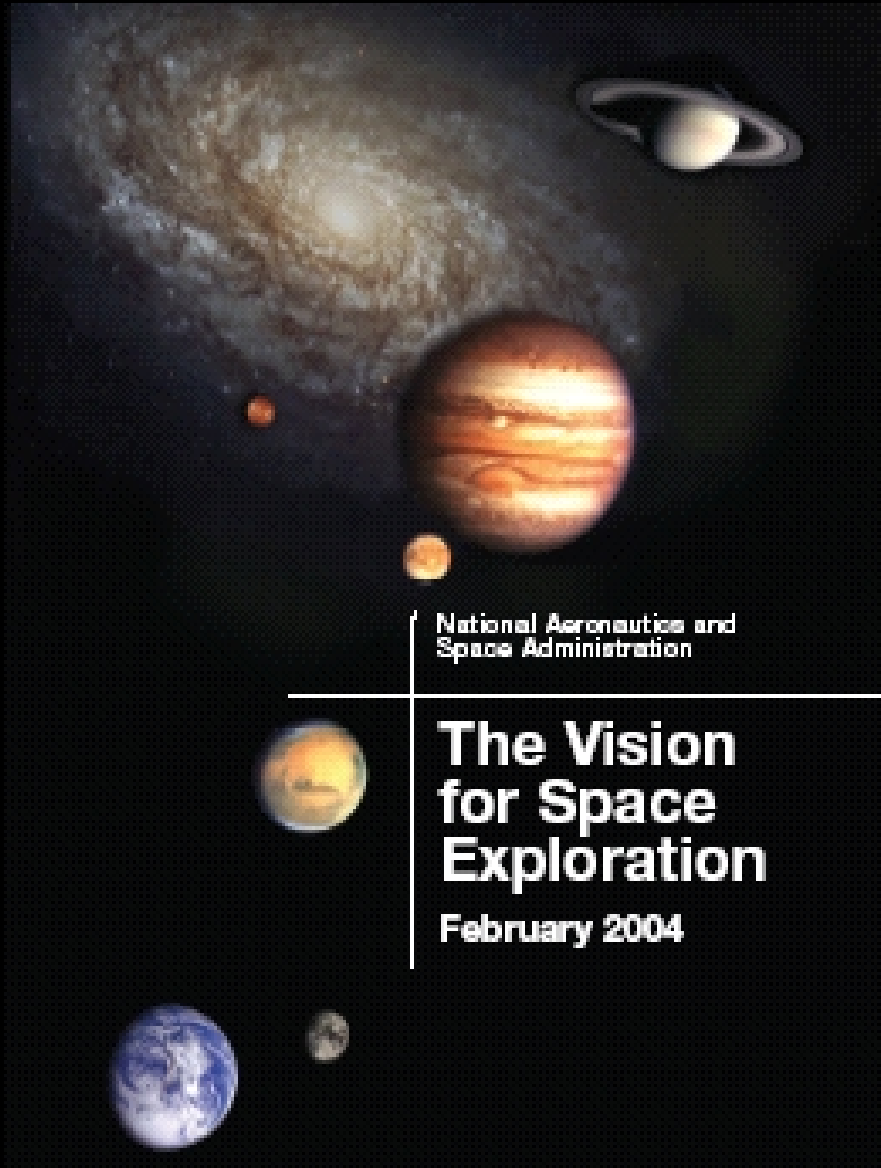
"... America will make those words come true."

President George W. Bush
January 14, 2004





Our aim is to explore in a sustainable, affordable, and flexible manner. We believe the principles and roadmap set down in this document will stand the test of time. Its details will be subject to revision and expansion as new discoveries are made, new technologies are applied, and new challenges are met and overcome.



Policy Goals

Sustained and affordable human and robotic program to explore the solar system and beyond

Extend human presence across the solar system

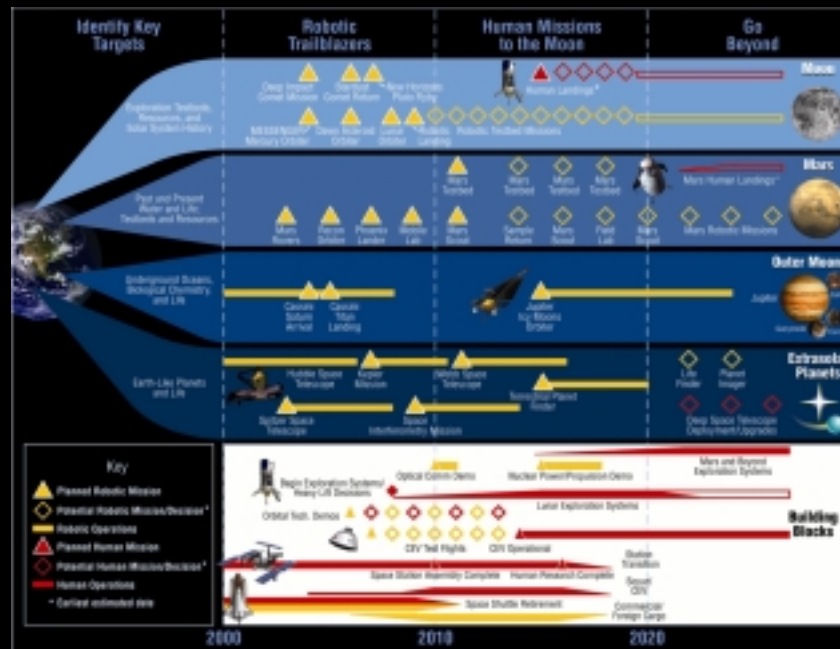
Develop innovative technologies, knowledge and infrastructures

Promote international and commercial participation in exploration



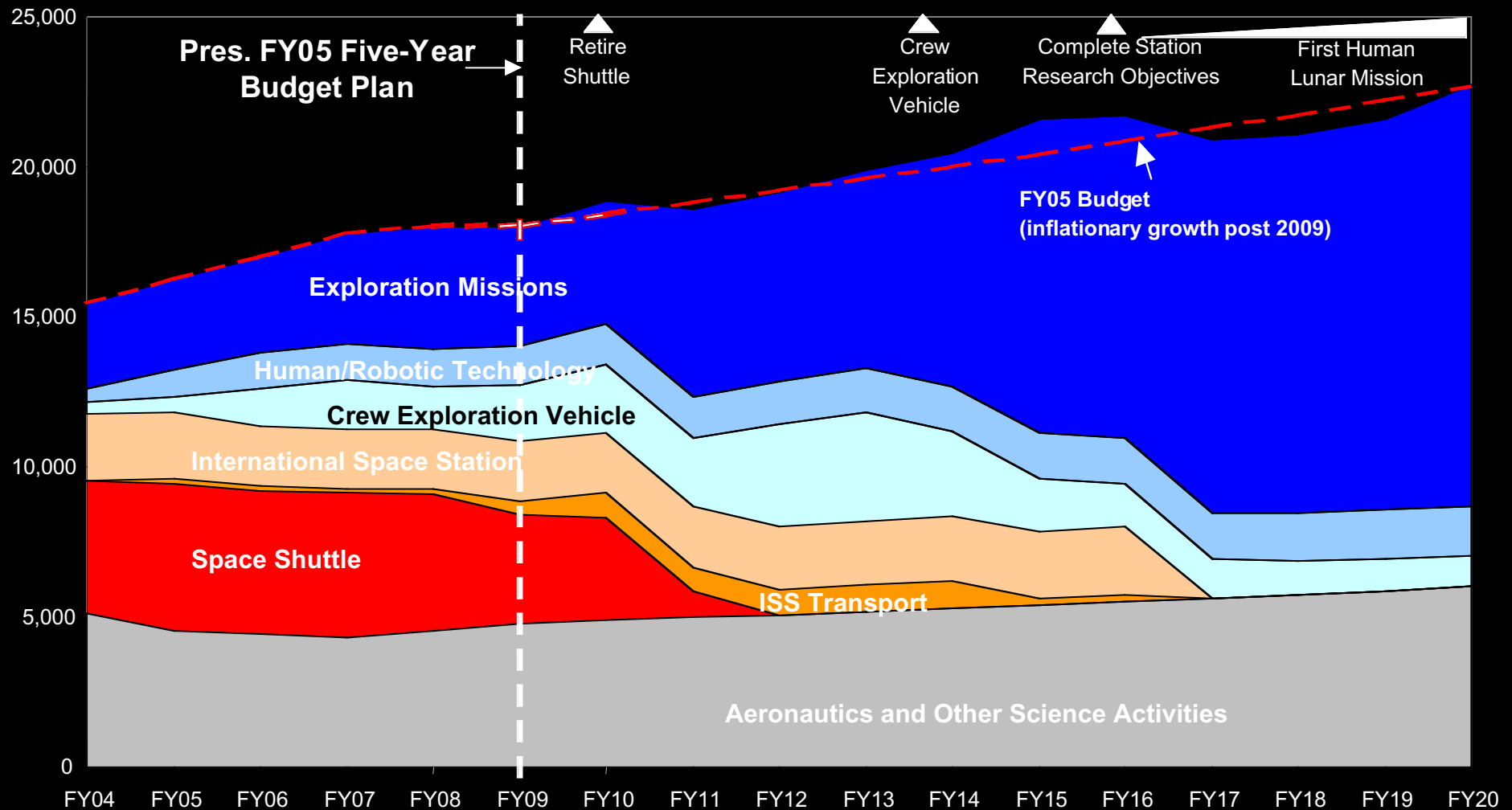
Exploration Program Elements

Consistent with *The President's Vision for U.S. Space Exploration*, NASA has set a new course for exploration and discovery, as summarized in the exploration roadmap. Implementation of the exploration vision will be informed by the recommendations of the Aldridge Commission.



Strategy Based on Long-Term Affordability

\$ in millions

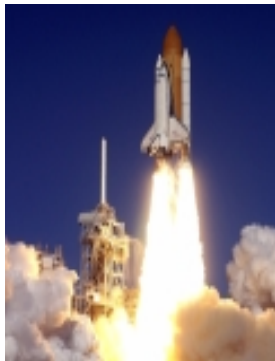


NOTE: Exploration missions — Robotic and eventual human missions to Moon, Mars, and beyond
 Human/Robotic Technology — Technologies to enable development of exploration space systems
 Crew Exploration Vehicle — Transportation vehicle for human explorers
 ISS Transport — US and foreign launch systems to support Space Station needs especially after Shuttle retirement

Organizational Changes

To successfully execute the exploration vision, NASA will focus its organization, create new offices, align ongoing programs, experiment with new ways of doing business, and tap the great innovative and creative talents of our Nation.

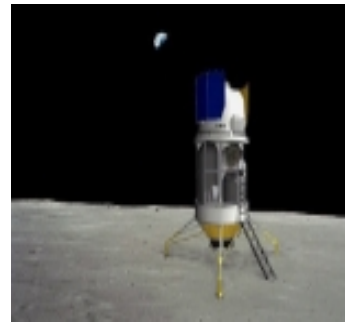
Space Flight



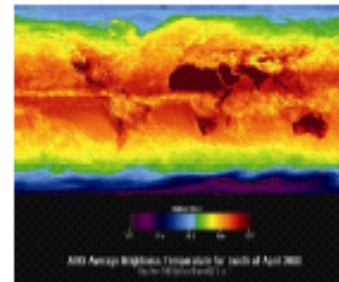
Aeronautics



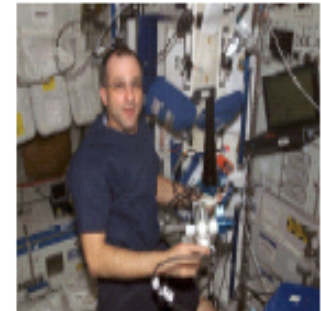
Exploration Systems



Earth Science



Biological / Physical

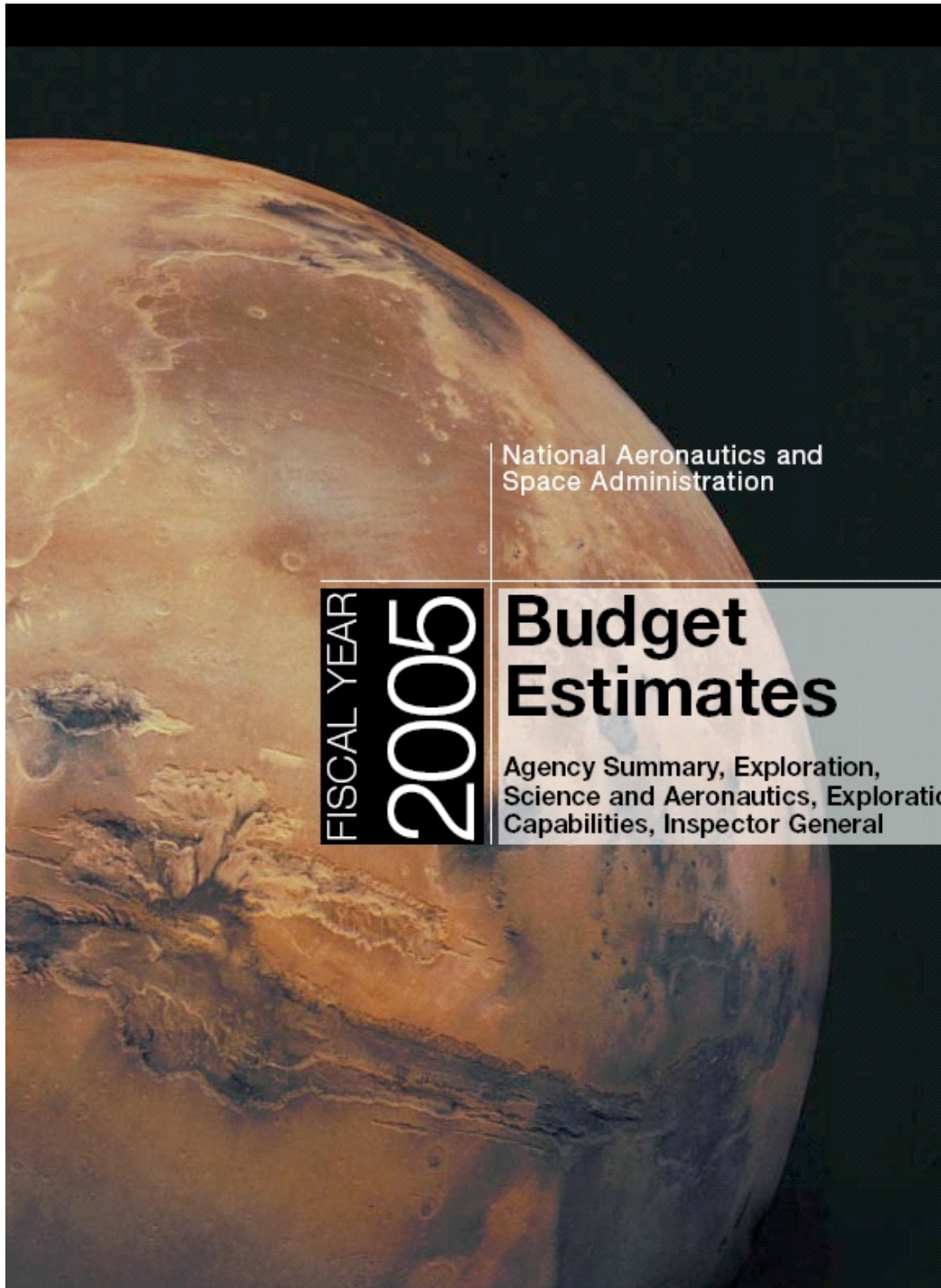


Space Science



Education





Starting Now

Space Shuttle Return To Flight

Return the Space Shuttle to flight as soon as practical, based on the recommendations of the Columbia Accident Investigation Board



Space Shuttle Phase Out



*Focus use of Space Shuttle to
complete ISS assembly*



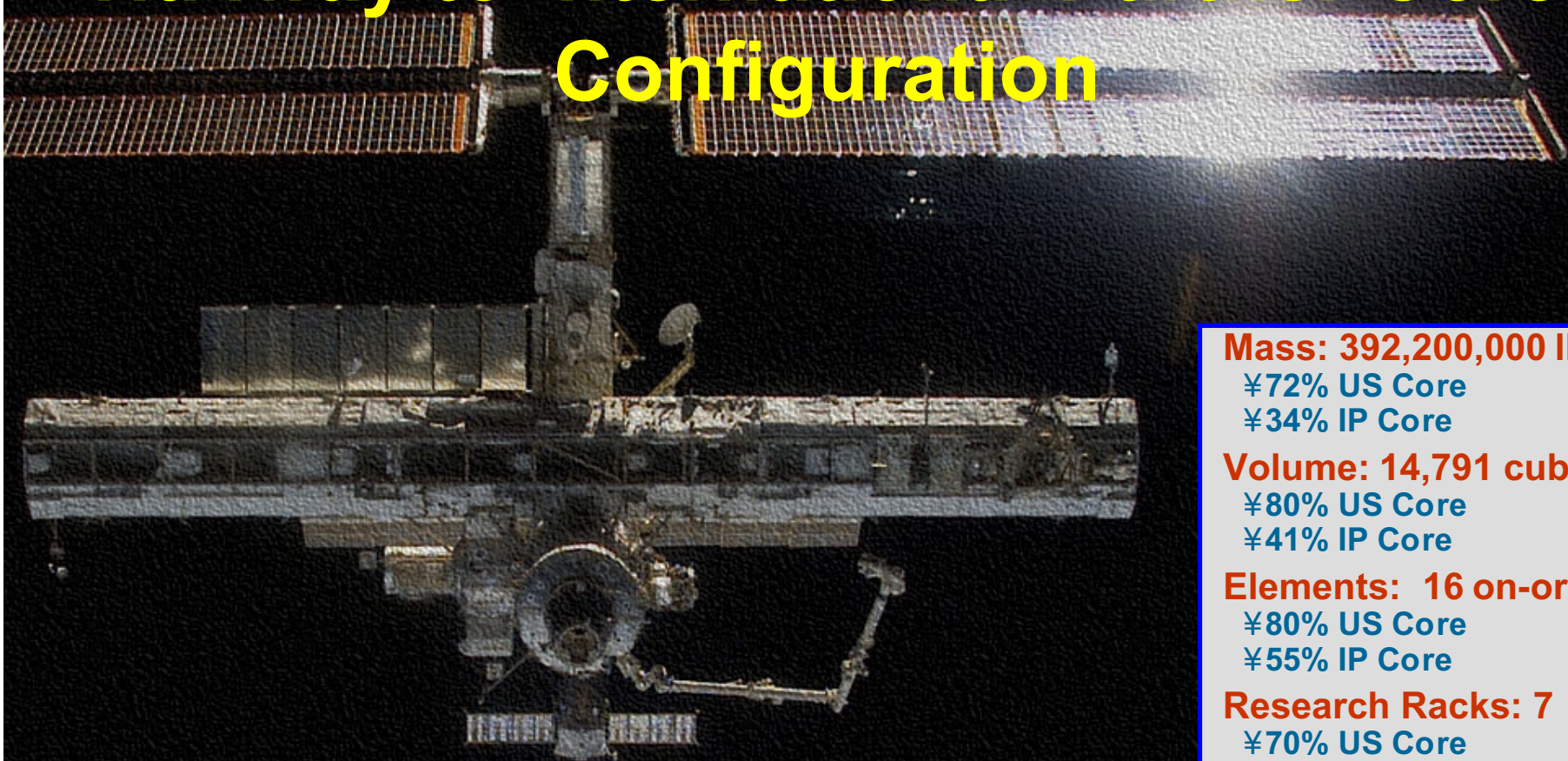
*Retire the Space Shuttle as
soon as ISS assembly
completed, planned for the
end of this decade*

Complete The International Space Station

Complete assembly of the International Space Station, including the U.S. components that support U.S. space exploration goals and those provided by foreign partners, planned for the end of this decade



Halfway to International Partner Core Configuration



Mass: 392,200,000 lbs

¥72% US Core

¥34% IP Core

Volume: 14,791 cubic ft

¥80% US Core

¥41% IP Core

Elements: 16 on-orbit

¥80% US Core

¥55% IP Core

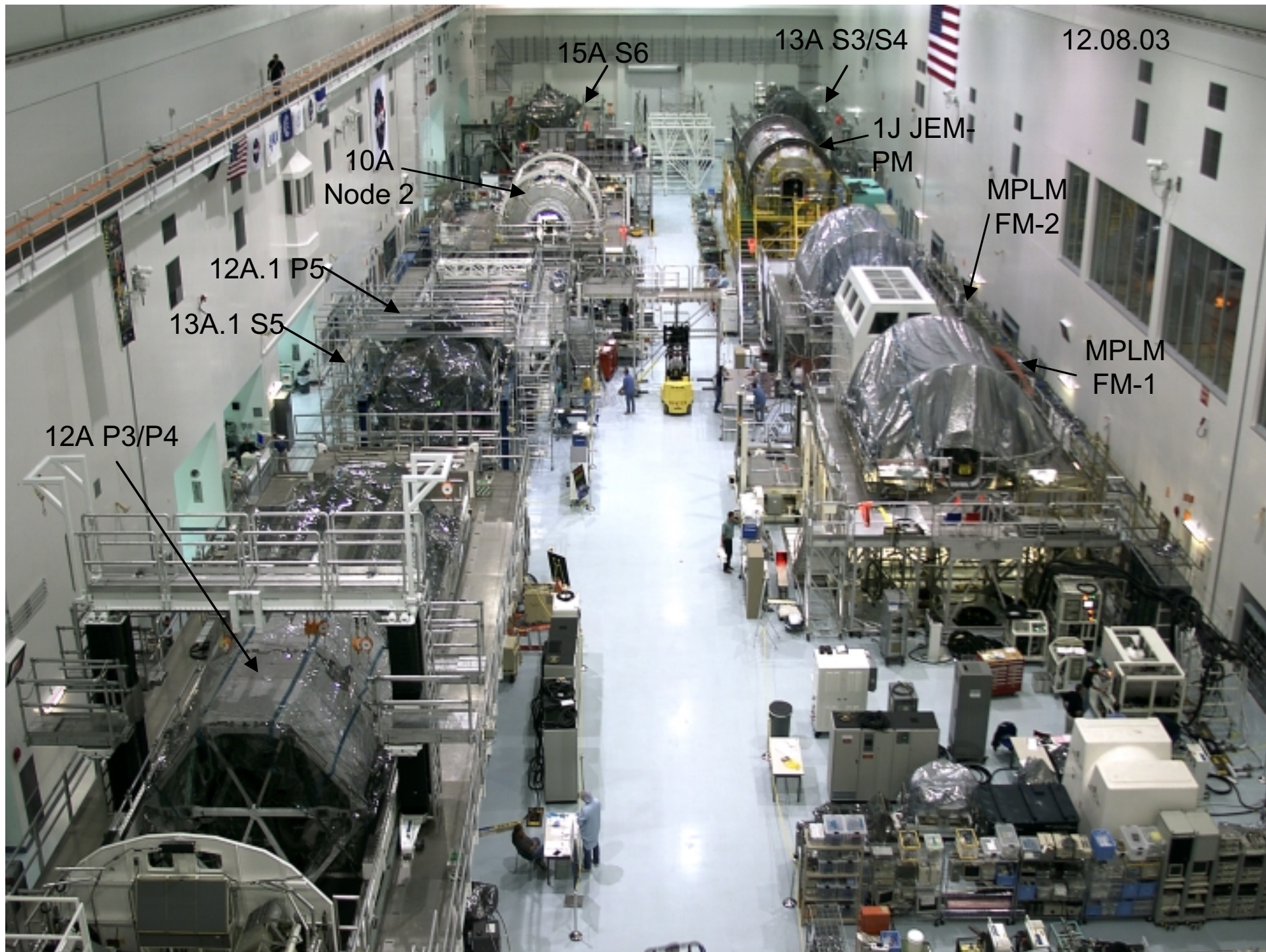
Research Racks: 7

¥70% US Core

¥27% IP Core

Elements On-Orbit

- | | |
|---------------------------------|---|
| ¥ FGB Zarya | ¥ CanadArm 2, Mobile Base System &Transporter |
| ¥ Unity Node and Destiny Lab | ¥ Quest U.S. Airlock |
| ¥ 3 Pressurized Mating Adapters | ¥ Pirs Russia Docking Compartment |
| ¥ Service Module Zvezda | ¥ S0 Central Power Data Truss |
| ¥ Z1 Truss | ¥ S1 Right Truss |
| ¥ P6 Solar Array | ¥ P1 Left Truss |



Space Station Status Today

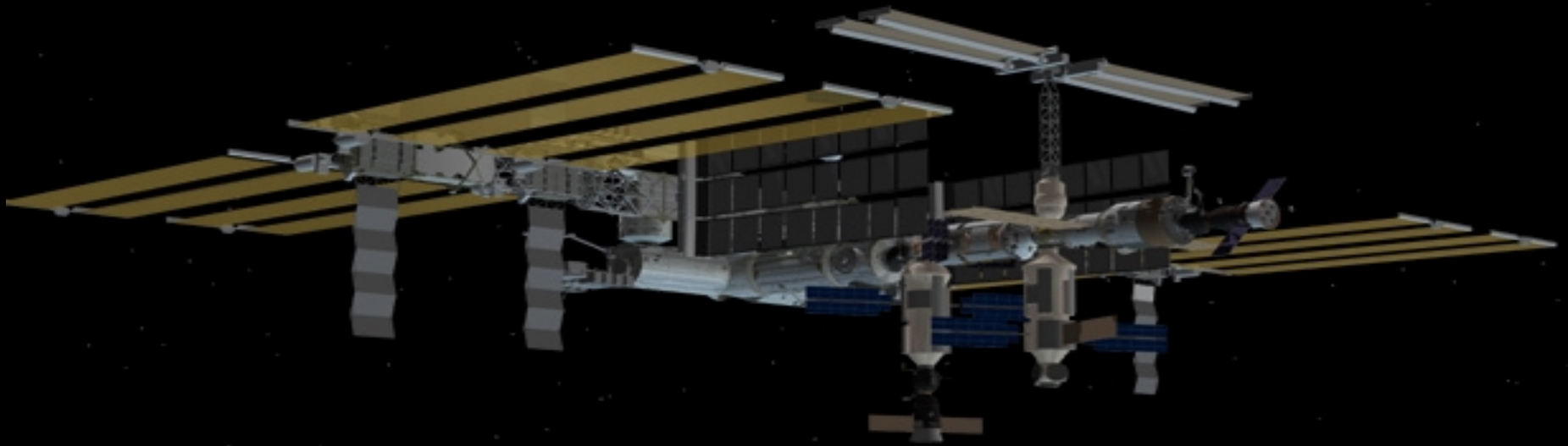
- ¥ Crew restricted to two
- ¥ Assembly on hold
- ¥ Dependent on partnership for crew exchange and resupply
- ¥ Critical consumables currently on board are maintainable thru Spring 2004
- ¥ Hardware in good shape
- ¥ Limited science continues



Use ISS as a Stepping Stone

Focus U.S. research and use of the International Space Station on supporting space exploration goals, with emphasis on understanding how the space environment affects astronaut health and capabilities and developing countermeasures

Conduct International Space Station activities in a manner consistent with U.S. obligations contained in the agreements between the United States and other partners in the International Space Station.



Lunar Exploration

Undertake lunar exploration activities to enable sustained human and robotic exploration of Mars and more distant destinations in the solar system

Starting no later than 2008, NASA will initiate a series of robotic missions to the Moon

NASA will conduct the first extended human expedition to the lunar surface as early as 2015



Use the Moon as a Testing Ground

Use lunar exploration activities to further science, and to develop and test new approaches, technologies, and systems, including use of lunar and other space resources, to support sustained human space exploration to Mars and other destinations.

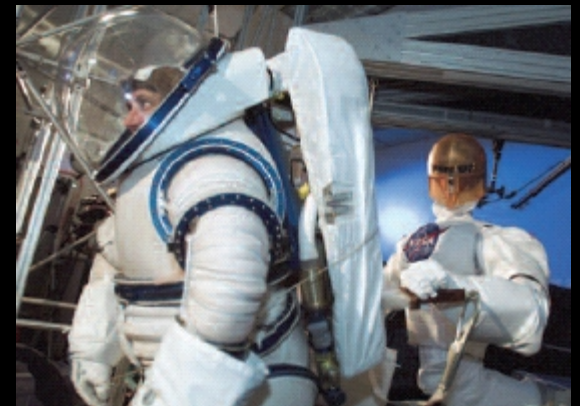


Human and Robots as Partners

NASA will send human and robotic explorers as partners, leveraging the capabilities of each where most useful.

Robotic explorers will visit new worlds first, to obtain scientific data, assess risks to our astronauts, demonstrate breakthrough technologies, identify space resources, and send tantalizing imagery back to Earth.

Human explorers will follow to conduct in-depth research, direct and upgrade advanced robotic explorers, prepare space resources, and demonstrate new exploration capabilities.



Robotic Exploration of Mars

Conduct robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration



The stunning images we are now receiving from the *Spirit* and *Opportunity* rovers at Mars are just the beginning.

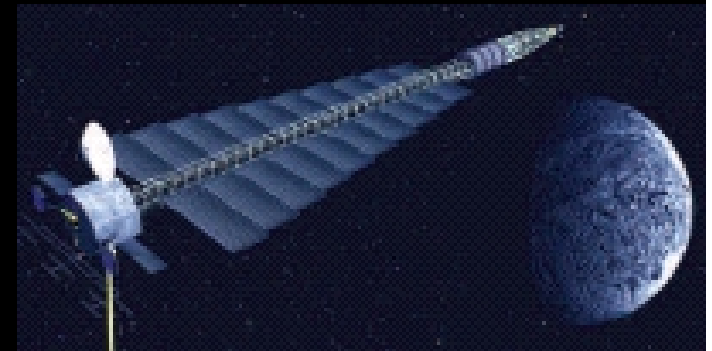


Robotic Exploration of the Solar System



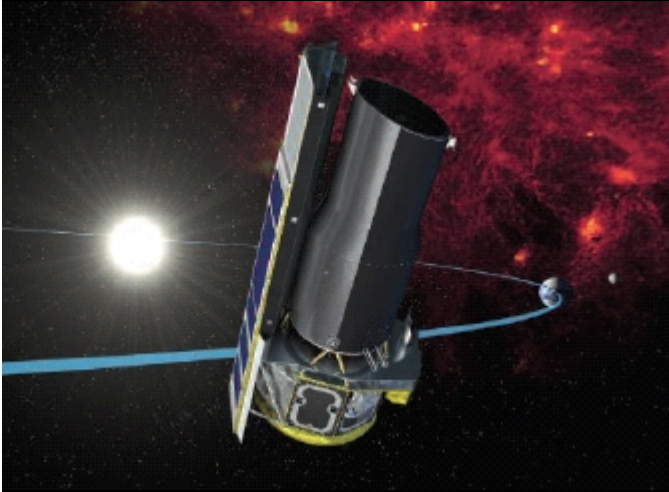
Conduct robotic exploration across the solar system for scientific purposes and to support human exploration. In particular, explore Jupiter's moons, asteroids and other bodies to search for evidence of life, to understand the history of the solar system, and to search for resources

Over the next two decades, NASA will send increasingly advanced robotic probes to explore our solar system and beyond, including Earth's Moon, Mars, the moons of Jupiter, and other outer planets, and launch new space telescopes to search for planets beyond our solar system.

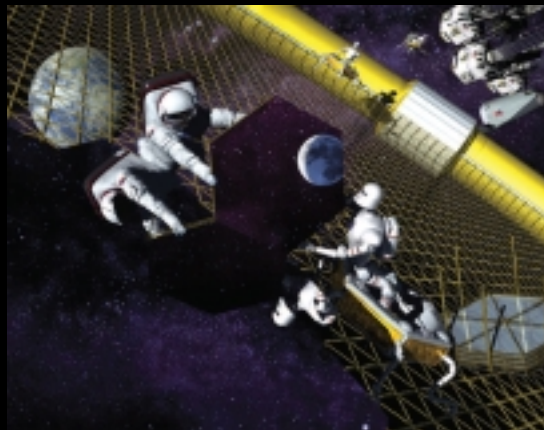
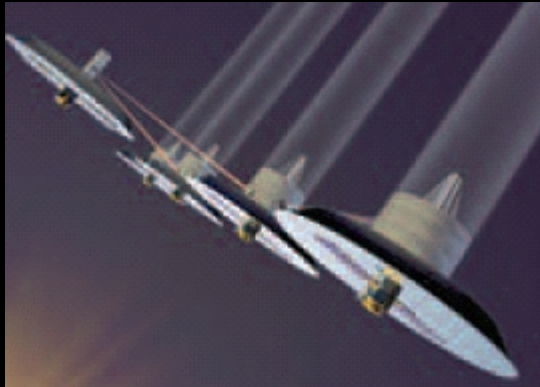


Enhanced Robotic Trailblazers

Conduct advanced telescope searches for Earth-like planets



In this decade alone, NASA plans to launch at least two robotic missions to the Moon, five robotic missions to Mars, three space telescopes that will expand our search for planets circling other stars, and four missions to other planets, comets, and asteroids.



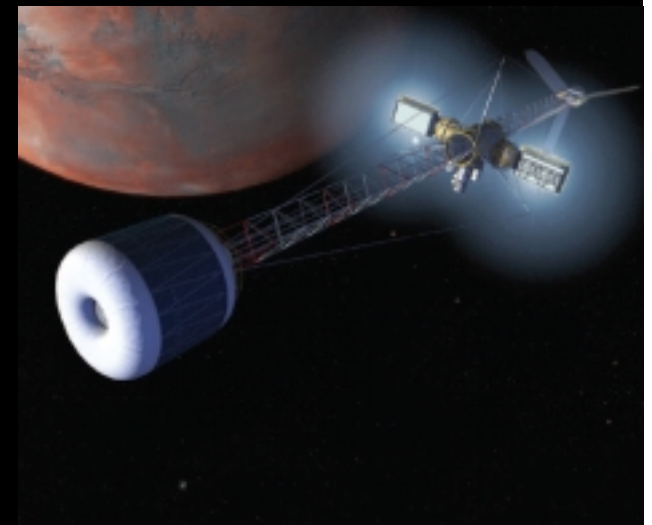
Technology Development

Develop and demonstrate power generation, propulsion, life support and other key capability



Breakthrough technologies, such as nuclear power and propulsion, optical communications, and potential use of space resources, will be demonstrated as part of robotic exploration missions.

The challenges of designing these systems will accelerate the development of fundamental technologies that are critical not only to NASA, but also to the Nation's economic and national security



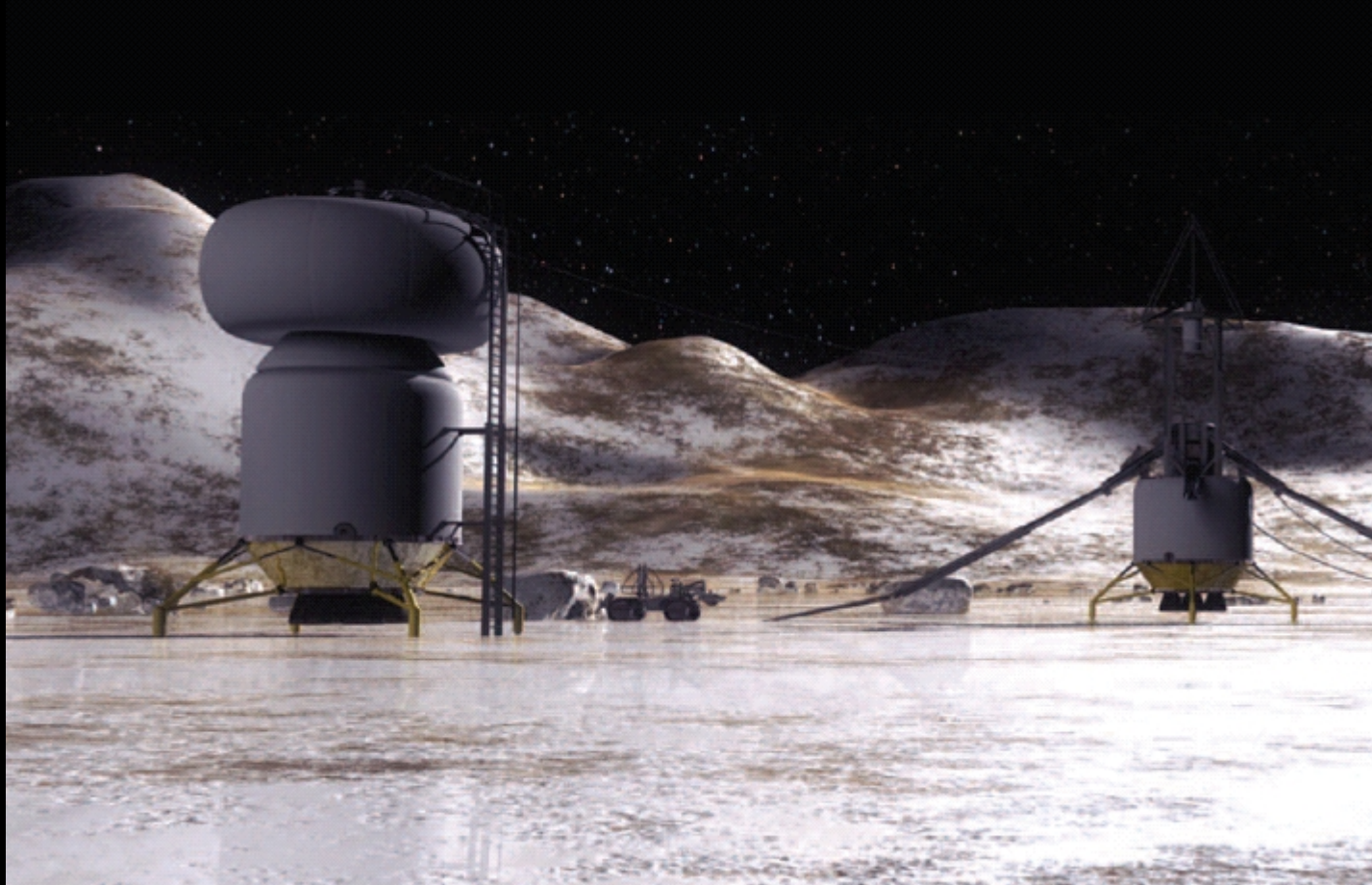
Mars As A Destination

Conduct human expeditions to Mars after acquiring adequate knowledge

The timing of the first human research missions to Mars will depend on discoveries from robotic explorers, the development of techniques to mitigate Mars hazards, advances in capabilities for sustainable exploration, and available resources

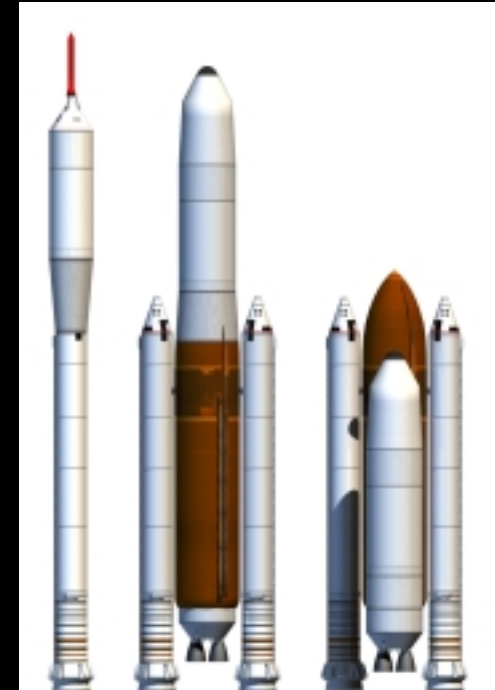


Other Destinations



Space Transportation Capabilities

Develop a new crew exploration vehicle to provide crew transportation for missions beyond low Earth Orbit



For future crew transport, NASA will undertake *Project Constellation* to develop a Crew Exploration Vehicle (CEV).

The CEV will be developed in stages, with the first automated test flight in 2008, more advanced test flights soon thereafter, and a fully operational capability no later than 2014.



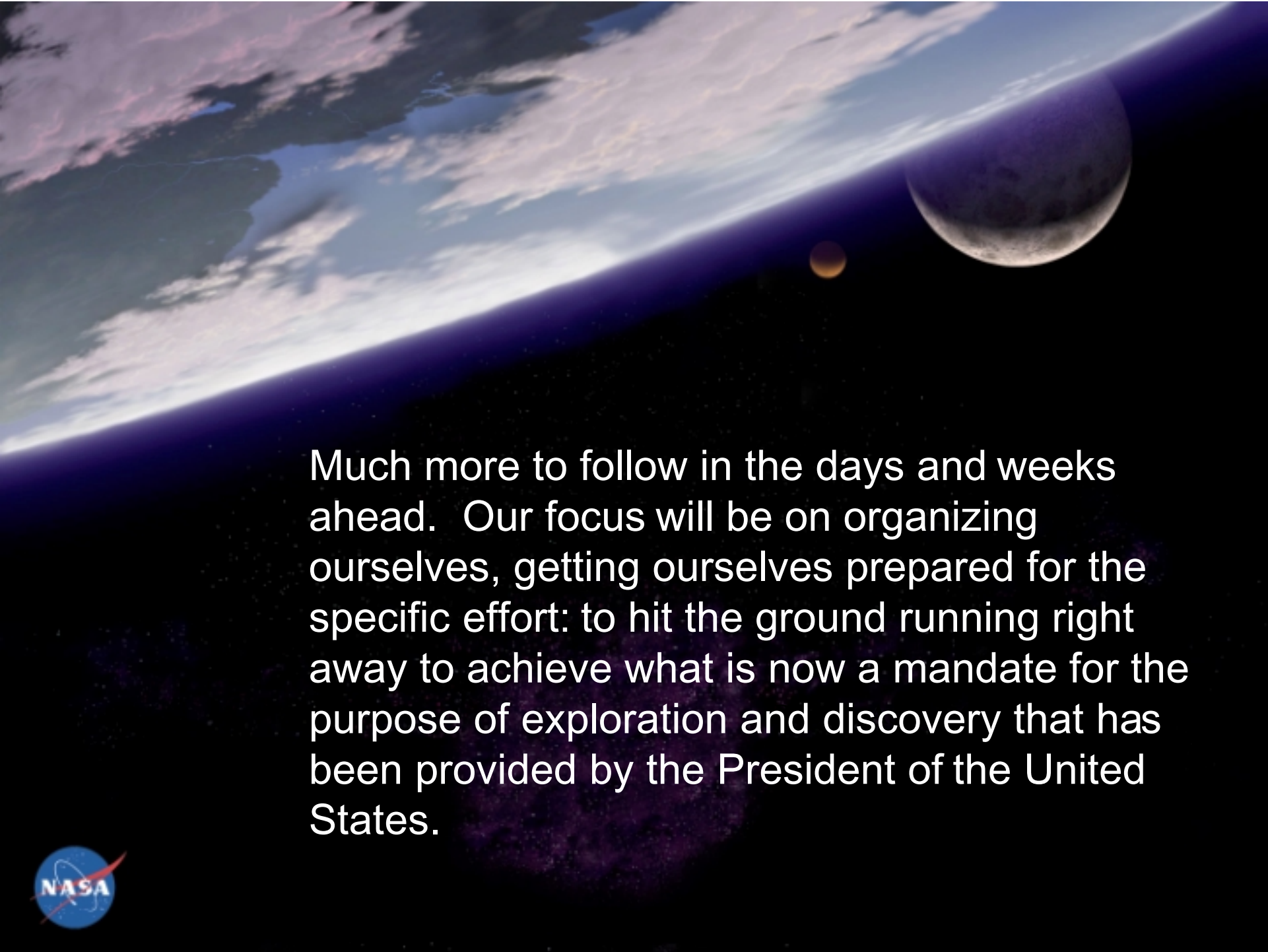
International Participation

Pursue opportunities for international participation to support U.S. space exploration goals



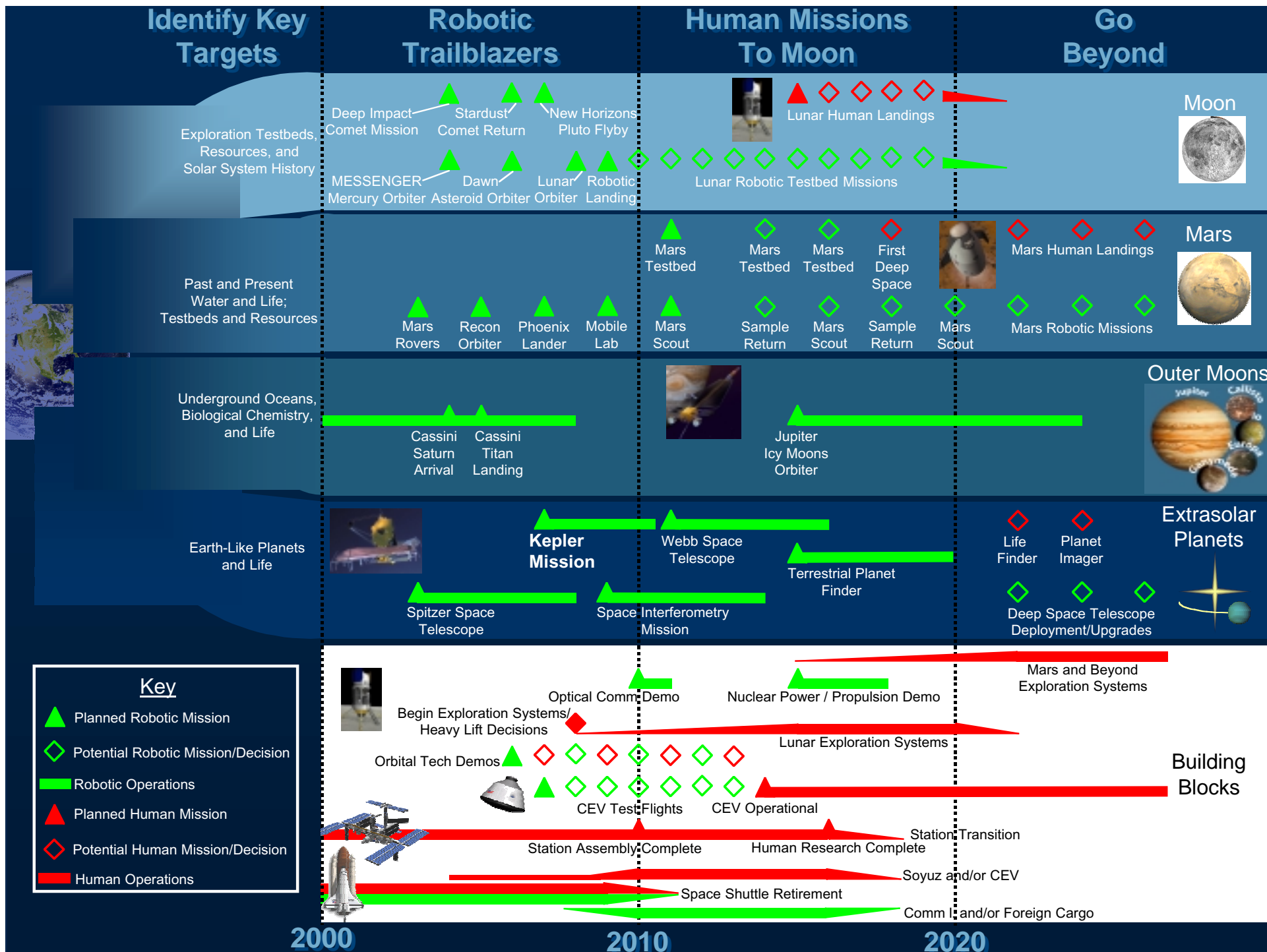
Current International Participation
In the Space Station

NASA will actively seek international partners and lead the space agencies of these partners in executing exploration activities.

A composite image showing the Earth's horizon, a large full moon, and a small orange planet in space. The Earth's horizon is a curved line separating the dark blue and purple sky from the white clouds. The full moon is a large, bright, circular object in the upper right. The small orange planet is a tiny, glowing sphere in the center. The background is a dark, starry space.

Much more to follow in the days and weeks ahead. Our focus will be on organizing ourselves, getting ourselves prepared for the specific effort: to hit the ground running right away to achieve what is now a mandate for the purpose of exploration and discovery that has been provided by the President of the United States.





OBPR's Organizing Questions

(http://spaceresearch.nasa.gov/general_info/strat_lite.html)

Humans will extend the exploration of space.
To prepare for and hasten the journey, OBPR
must answer these questions through its
research:



How can we assure the survival of humans traveling far
from earth?

How does life respond to gravity and space environments?

What new opportunities can our research bring
to expand our understanding of the laws of nature
and enrich lives on Earth?

What technology must we create to enable the next
explorers to go beyond where we have been?

How can we educate and inspire the next generation to
take the journey?

Organizing Question 1. How can we assure the survival of humans traveling far from Earth?

	Today	2004-2008	2009-2016
<i>Mitigate and manage human adaptation risks</i>	<p>55 risks identified for outcome-driven research</p> <p>Promising countermeasures identified and studied</p> <p>Knowledge obtained using ground-based mechanistic studies</p>	<p>Characterize and assess critical risks</p> <p>Advance understanding of mechanisms</p> <p>Develop and test candidate countermeasures using ground-based analogs and space flight</p>	<p>Evaluate and validate system-targeted countermeasures to prevent or reduce risks</p> <p>Complete initial in-flight testing of countermeasures (artificial gravity with other countermeasures)</p>
<i>Reduce uncertainties and prevent exposure to space radiation environments</i>	<p>Uncertainties exist in estimating radiation risks</p> <p>Study of mechanistic effects in work</p> <p>Exposure mitigated using EVA scheduling and dose limits</p>	<p>Reduce uncertainty by one-half</p> <p>Expand mechanistic understanding using other models</p> <p>Develop and test new countermeasures</p>	<p>Assure at a 95% confidence interval crewmembers will not exceed radiation risk limits for longer-duration missions</p> <p>Test and evaluate biomedical and operational countermeasures</p>
<i>Maintain behavioral health and optimal function of crews</i>	<p>Psychosocial functioning and behavioral health status studied for individuals</p> <p>Sleep protocols implemented</p> <p>Psychosocial function and performance studied for small groups in remote settings</p>	<p>Identify key psychosocial and psychological stressors</p> <p>Develop and test assessment methods, tools, and models</p> <p>Develop and test optimized countermeasures through ground and space research</p>	<p>Complete identification and increased understanding of psycho-social and behavioral health issues</p> <p>Validate assessment methods and tools</p> <p>Verify and validate countermeasure strategies</p>
<i>Develop autonomous medical care capabilities</i>	<p>Stabilize and return medical care model developed</p> <p>Screening and select-in criteria in place for current mission scenarios</p>	<p>Develop standardized approach to track health status</p> <p>Determine clinical trends and define acceptable levels of risk</p> <p>Perform research to enhance medical capabilities, including screening, countermeasures, and treatment regimens</p>	<p>Determine acceptable levels of risk for longer-duration missions and validate countermeasures</p> <p>Identify and assess crew screening and certification for longer-duration missions</p> <p>Demonstrate autonomous medical care capabilities</p>
Research Capabilities	Ground labs including analogs, Shuttle, ISS	Ground labs including analogs, Shuttle, ISS	Ground labs including analogs and integrated testing, Shuttle, ISS, free flyers

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Ability of humans to retain function and remain healthy during and after long-duration missions beyond low-Earth orbit

Organizing Question 2. How does life respond to gravity and space environments?

	Today	2004-2008	2009-2016
<i>Determine how genomes and cells respond to gravity</i>	Data on various cell types collected in short-term studies	Develop physical and genetic models of cellular responses to space environments for a variety of organisms	Develop cell-based model assays to identify cellular systems affected by space; Integrate biological effects with cell communications
<i>Determine how gravity affects organisms and physiology</i>	Incomplete life cycle and ground-based data gathered from short-duration flights	Use ground-based simulators, nanosatellites and ISS to determine gravity responses for a wide variety of organisms	Determine gravity thresholds and developmental responses in space using centrifuges on ISS
<i>Understand interactions among groups of simple and complex organisms</i>	Ground-based virulence studies performed, lack systems supporting mixed organisms in space	Model effects of space environments on pathogenic and cooperative interactions among species	Identify microorganisms that become pathogenic or otherwise alter function in space environments
<i>Determine how Earth-based life can best adapt to different space environments through multiple generations</i>	Preliminary multi-generation flight research performed on plants	Raise species from multiple kingdoms through several generations in flight; focus on reproductive success	Raise mammals through multiple generations in flight; investigate developmental adaptations and critical issues
Research Capabilities	Ground labs, Shuttle, ISS	Ground labs, Shuttle, ISS, nanosatellites	Ground labs including analogs and integrated testing, Shuttle, ISS, free flyers

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Ability to predict responses of cells, molecules, organisms, and ecosystems to space environments

Organizing Question 3. What new opportunities can our research bring to expand understanding of the laws of nature and enrich lives on Earth?

	Today	2004-2008	2009-2016	O U T C O M E Application of physical knowledge to new technologies and processes, particularly in areas of power, materials, manufacturing, fire safety New insights into theories on fundamental physics, physical/chemical processes, and self-organization in structure
<i>Determine how space environments change physical and chemical processes</i>	Research hampered by gravity-driven effects; gravity effects not understood in many technologies	Conduct ground and flight research to develop and validate models for fluid, thermal, combustion, and solidification processes	Test extended range models for heat transfer and microfluidic control, combustion validation; nanotechnology-based materials with enhanced and adaptive properties	
<i>Understand how structure and complexity arise in nature</i>	Limited experimental data collected on self-assembly, self-organization, and structure development processes	Conduct ground and space research in solidification dynamics, colloidal photonics, carbon nanostructures	Research new technologies for advanced photonic materials Test solidification models using industrial systems Conduct flight investigations in combustion, granular material systems, and flows	
<i>Understand the fundamental laws governing time and matter</i>	Data of unprecedented accuracy obtained in microgravity	Conduct research in dynamics of quantum liquids, atomic clock reference for space Develop technology for nanogravity satellite relativity experiments	Test Bose-Einstein condensates atom laser theories Use satellite experiments to test second-order models of general relativity	
<i>Identify the biophysical mechanisms that control the cellular and physiological behavior observed in the space environment</i>	Results obtained from Earth-based bioreactor and space-based tissue culture need validation; space-based improvements in protein crystal structures need validation	Conduct tissue-based research and engineering in space test models for fluid-stress and cellular response mechanisms Quantify key physiological signals Complete space-based flight research and establish validation of impact on structural biology	Test control strategies for cellular response to fluid stresses Integrate NASA technologies and research with biomedical needs	
Research Capabilities	Ground labs, Shuttle, ISS, KC-135 aircraft	Ground labs, Shuttle, ISS, KC-135 aircraft	Ground labs, Shuttle, ISS, KC-135 aircraft, free flyers	

Organizing Question 4. What technology must we create to enable the next explorers to go beyond where we have been?

	Today	2004-2008	2009-2016	O U T C O M E New technologies that provide for more efficient, reliable, and autonomous systems for sustainable human presence beyond low-Earth orbit
<i>Increase efficiency through life-support system closure</i>	<p>Current ISS baseline is a 90-day resupply</p> <p>Components with improved efficiency are the focus</p>	<p>Develop technologies that lower Equivalent System Mass (ESM)</p> <p>Perform integrated testing of lower ESM life-support technologies and subsystems in relevant environments</p>	<p>Perform on-orbit validation of critical components and certification of life-support technologies for missions beyond LEO</p> <p>Perform integrated testing of life-support systems with humans in the loop</p>	
<i>Enable engineering systems and advanced materials for safe and efficient space travel</i>	<p>High-mass/cost, low-performance materials used</p> <p>Understanding of low- and partial-gravity issues incomplete</p>	<p>Develop and test low- and partial-gravity fluid and thermal engineering systems</p> <p>Develop and test design tools for advanced materials and in-space fabrication, and validate on ISS</p>	<p>ISS experiments to test prototype engineering systems</p> <p>Complete development of advanced materials for radiation-shielding solutions</p> <p>Validate prototype low- and partial-gravity resource-generation technologies</p>	
<i>Enable self-supporting and autonomous human-systems for performance in habitable environments</i>	<p>Predictive methods and models limited for habitability analysis, information management, crew training, multi-agent team task analysis, integrated human systems engineering</p>	<p>Define and develop habitats that optimize human performance</p> <p>Develop tools and models for human-systems integration</p>	<p>Validate habitat designs for multiple missions</p> <p>Validate human-system design simulation</p> <p>Deliver validated design requirements and integrated simulation tools for multiple missions</p>	
<i>Develop advanced environmental monitoring and control systems</i>	<p>Technologies exist for partial monitoring of ISS environment</p> <p>Individual sensors developed</p>	<p>Develop sensing capabilities for 90% of existing air Spacecraft Maximum Allowable Concentrations</p> <p>Develop sensing capabilities to monitor water</p> <p>Develop autonomous controls architecture design</p>	<p>Develop miniaturized, real-time, efficient sensing capabilities for air and water</p> <p>Validate integrated systems</p>	
Research Capabilities	Ground facilities, simulators, Shuttle, ISS, KC-135 aircraft	Ground facilities, Shuttle, ISS, KC-135 aircraft	Integrated ground test facilities, Shuttle, ISS, KC-135 aircraft, free flyers	